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A CONTRIBUTION TO THE STUDY OF MUSCULAR TREMOR.[1]

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PATHOLOGICAL motor disturbances present a wide and interesting field for study, too wide and varied for review in a short paper. Hence, grosser movements, such as the choreiform, athetoid and epileptiform will not be considered here. I have a few words to say upon the finer pathological motions known as muscular tremblings or tremors, such as are found in hysteria, neurasthenia, multiple sclerosis, paralysis agitans, morbus Basedowii, senility, and in poisoning by mercury, lead, alcohol, tobacco, etc., many of which resemble the physiological tremors produced by the action of cold upon the body, and of the depressing emotion fear.

The origin of rhythmical motions of all kinds has been a matter for much speculation. For the coarser oscillations of the different forms of eclampsia and chorea the theory ascribing their usual genesis to explosions of force in the cortical cells of the motor areas of the brain is generally accepted. But the origin of the finer tremors is more mysterious, and the formation of a hypothesis concerning them more difficult. Have they their origin in the nervous system or in the muscular tissue itself? If in the nervous system is it peripheral or central?

In physiology we have learned that curara paralyzes the motor nerve endings, and that the sartorius of a curarized frog when dipped in a saline solution will contract rhythmically for several days (Biedemann).[2]

[1] Read before the American Neurological Association, at Washington, D. C. Sept. 20, 1888.

[2] Landois and Sterling. Text Book of Human Physiology, 2d ed., p. 510.

The so-called fibrillar contractions[3] occur in the muscles of the tongue after section of the hypoglossal nerve (Schiff), and in the muscles of the face after section of the facial nerve. According to Bleuler and Lehmann these may take place for six months in the tongues of rabbits after section of the hypoglossal. Some drugs cause such fibrillar contractions, as aconitin, guanidin, pilocarpin and physostigmin, according to Brunton by irritating the motor nerve-endings, for the contractions are gradually abolished by curara. Such phenomena may be termed idio-muscular. Yet the researches of Gerlach tend to obscure the doctrine of specific muscular irritability by showing that a nerve fibre on penetrating the sarcolemma divides into inter-fibrillar threads, which come into direct relation with the sarcous substance.

Now as regards the physiological action of muscle through the mediation of the nervous system, we learn that a continued voluntary contraction in man consists of a series of single contractions rapidly following each other, frequent intermittent vibrations which reach their maximum when a person shivers (E. Weber).

Tetanus is a condition of continuous vibratory contraction, an accumulation of contractions which follow each other too rapidly for relaxation to take place.

Horsley and Schäfer[4] have demonstrated that such contractions, whether natural or not, are caused by impulses from the central nervous system along the motor nerves, discharged rhythmically at the rate of ten per second. This innervation rhythm may be generated in the motor cells of the spinal cord, in the medulla, pons or mesencephalon, while the cortical cells may produce rhythmic impulses numbering twelve or thirteen per second.

J. von Kries, in a study of volitional muscular activity,[5] calls attention to familiar voluntary rhythmical movements, and the number that can be made per second. For instance, in the repetition of la-la-la the muscles engaged in articulation and moving the jaw cannot be made to exceed in fre-

[3] *Ibid.*, p. 512.

[4] Journal of Physiology, 1885, pages 96 and 111.

[5] *Archiv fur Physiologie, 1886.*

quency of contraction 6.2 per second. The fingers of a piano player are required to strike 11.2 tones per second in Chopin's Etude, op. 25, No. 2, and 12.3 per second in Czerny's *Schule der Fingerfertigkeit*, No. 1. Von Kries thinks that even this speed may be surpassed in short passages. The fastest voluntary movements of the wrist are about eight per second. The octave study, No. 8, in Chopin's opus 25, requires seven per second, while in the scherzo movement of Schumann's *Clavier quartette* the left hand must strike the keys rhythmically at the rate of eight times per second. Von Kries thinks that many virtuosos attain to a frequency of eleven per second. He used an instrument in his studies fashioned upon Marey's sphygmograph.

If we turn now to pathological conditions we find that the clonic spasms of epilepsy have a rhythm of ten or less per second ; and the ankle clonus may be easily determined to be at the rate of ten per second or less. Some of my tracings of ankle clonus are six per second. The movements in nystagmus are very variable, but are usually from one to three or four per second, occasionally too rapid for counting, as the application of any myographic apparatus to the eye is almost impossible.

Marie[6] examined the tremors of paralysis agitans and Basedow's disease. He found the rate of vibration five per second in the former disease, and eight to nine per second in exophthalmic goitre.

Charcot[7] pictures two myographic curves, one of multiple cerebro-spinal sclerosis and one from paralysis agitans. They are of no particular value, being half diagrammatic. He found the contractions of paralysis agitans to be four to five per second. Ewald[8] counted the oscillations also at five per second in this disease.

Grashey[9] made use of Marey's sphygmograph in the study of the rhythm of oscillation in four cases of paralysis agitans. He made tracings of the tremor of the right and

[6] *Contributions à l'étude et au diagnostic des formes frustes de la maladie de Basedow.*

[7] *Maladies du système nerveux.*

[8] *Berliner Klin Wochenschrift*, 1883, No. 32.

[9] *Archiv für Psychiatrie, Bd.* xvi, *S.* 857, 1885.

left hands and of the tongue. By this means he fixed the number of vibrations from 4.14 to 5.34 per second.

Huber,[10] by the application of Marey's sphygmograph to the bellies of the different muscles of the two arms, found that the number of oscillations varied from 3.43 to 5.57 per second. He also discovered that the rate of contraction varied in different muscles of the same person and in the same muscles on different days.

Gowers[11] shows some myographic tracings of tremor following hemiplegia, in paralysis agitans, insular sclerosis, general paresis, and hysteria in his new book. He makes the rate of oscillation in Parkinson's disease 4.8 to 7 per second, which is greatly in excess of the figures given by any other observer. Like Huber, he found considerable variation in different parts of the same person.

In my own studies of tremors I have also made use of a sphygmograph. I long ago abandoned the Marey sphygmograph for taking the pulse, and for three or four years have employed that manufactured by Edwards. Marey's was one of the earliest instruments invented, and the mechanical devices introduced between the pulse and the tracings are so crude and so lacking in delicacy that its use is open to many sources of error.

The Edwards sphygmograph (Fig. 1) possesses the highest qualities of mechanical precision and sensitiveness. The tracing needle and its adjustment are all in jeweled bearings and conical pivots with end jewels. It can be focused like a microscope, so to say, upon the pulse, by means of the milled nut on the barrel, and the vibrating blood column is brought as nearly as mechanical art can bring it into relation with the point of the tracing needle. Its sensitiveness is such that it may be easily applied to the tracing of fine oscillations of the tongue or fibrillary tremor in the lips. With this instrument I have been able to obtain beautiful transfers of muscular movements to paper. The myograms I present herewith will not exhibit the per-

[10] *Virchow's Archiv, Bd. cviii, S.* 45, *Myographische Studien bei Paralysis agitans.*

[11] Diseases of the Nervous System, 1888, p. 1001.

fection perhaps that instruments especially designed for the purpose might do; yet much can be learned from them as to the innervation rhythm and irregularities of various muscular tremors.

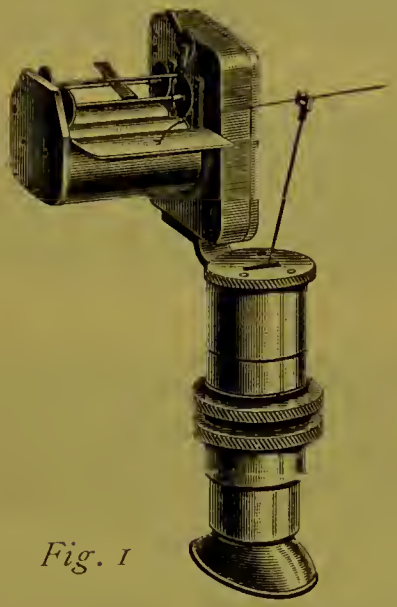
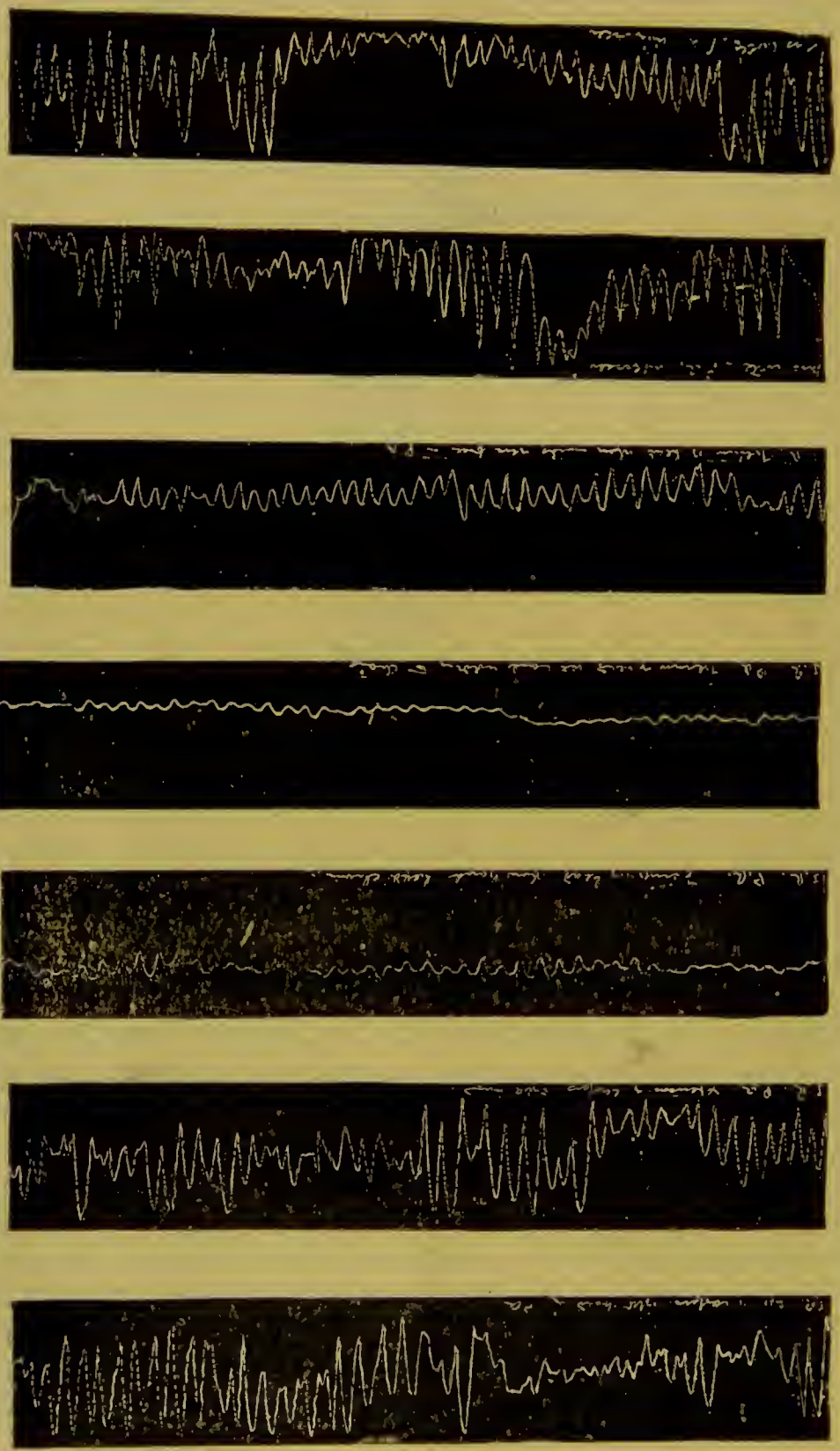


Fig. 1

In taking such tracings it will be found that the will of the individual upon whom the instrument is used greatly modifies the character of the vibrations. This must be expected, because we make, as is well known, a great distinction between tremors as regards this particular feature. We speak of the intention tremor of multiple sclerosis, where voluntary effort gives rise to the muscular oscillations, while in paralysis agitans, for instance, any volitional impulse usually suffices to momentarily interrupt vibration. Hence, in the application of the instrument to muscles exhibiting an intention tremor, any variation in the voluntary attempt to hold the member steady may either diminish or increase the extent of excursion. In paralysis agitans the patient is told when the instrument is in position to allow the limb to lie in perfect repose, but he is very apt to make an involuntary use of his will, if such an expression be permissible, and thus cause a momentary cessation of the tremor, or at least a decrease in the distance of oscillation. In such a series of muscular contractions as that of ankle clonus, the will is powerless to affect the motion of

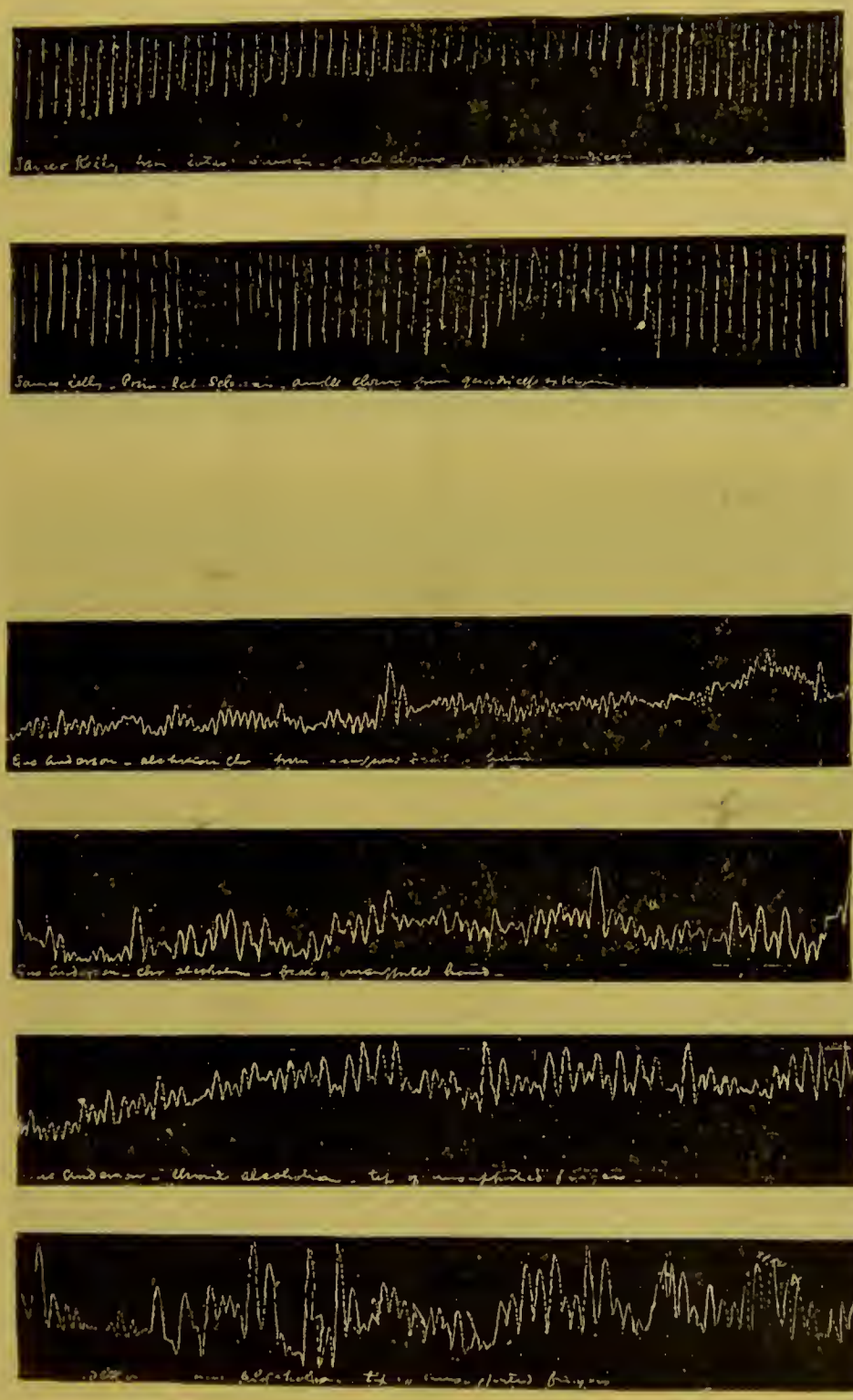
TEN SECONDS.



TREMOR OF PARALYSIS AGITANS.

1. Tremor of extensors of carpus of right hand, - - - 5.3 per second.
2. " " " " - - - - - 5.1 "
3. Tremor of head while hands held a chair, - - - - - 4.4 "
4. " " " " - - - - - 4.6 "
5. Tremor of head, no effort with hands to keep steady, - 4.8 "
6. Tremor of Interossei, Case No. II, - - - - - 4 5 "
7. " " " " - - - - - 4 9 "

TEN SECONDS.



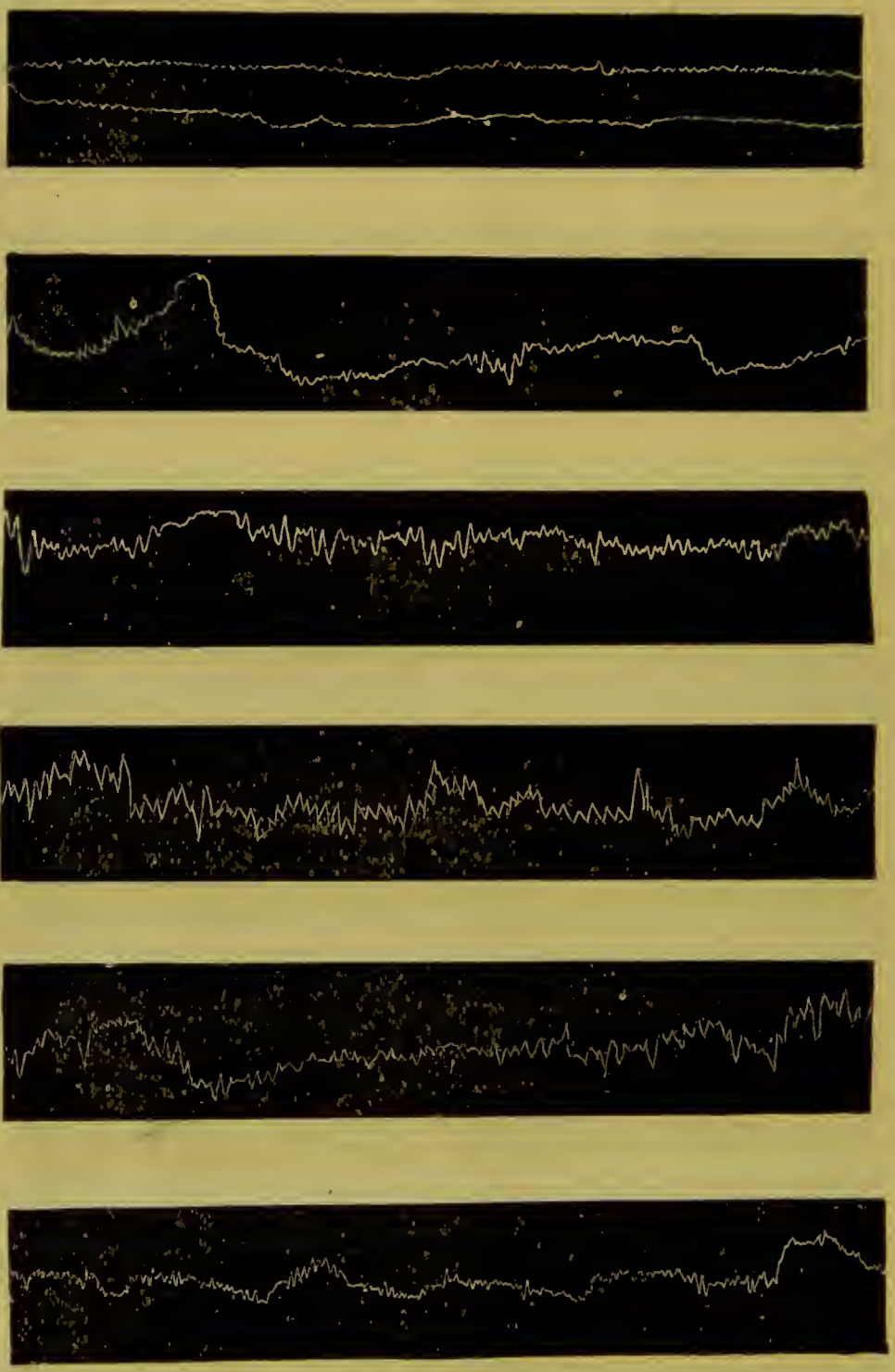
ANKLE CLONUS IN PRIMARY LATERAL SCLEROSIS.

1. From top of knee, - - - - - - - - 6 per second.
2. " " - - - - - - - - - - 6 "

TREMOR OF CHRONIC ALCOHOLISM.

3. From back of unsupported hand, - - - - 11.2 "
4. " " " " - - - - - 8.5 "
5. From tip of unsupported fingers, - - - - 9 "
6. " " " " - - - - 8.9 "

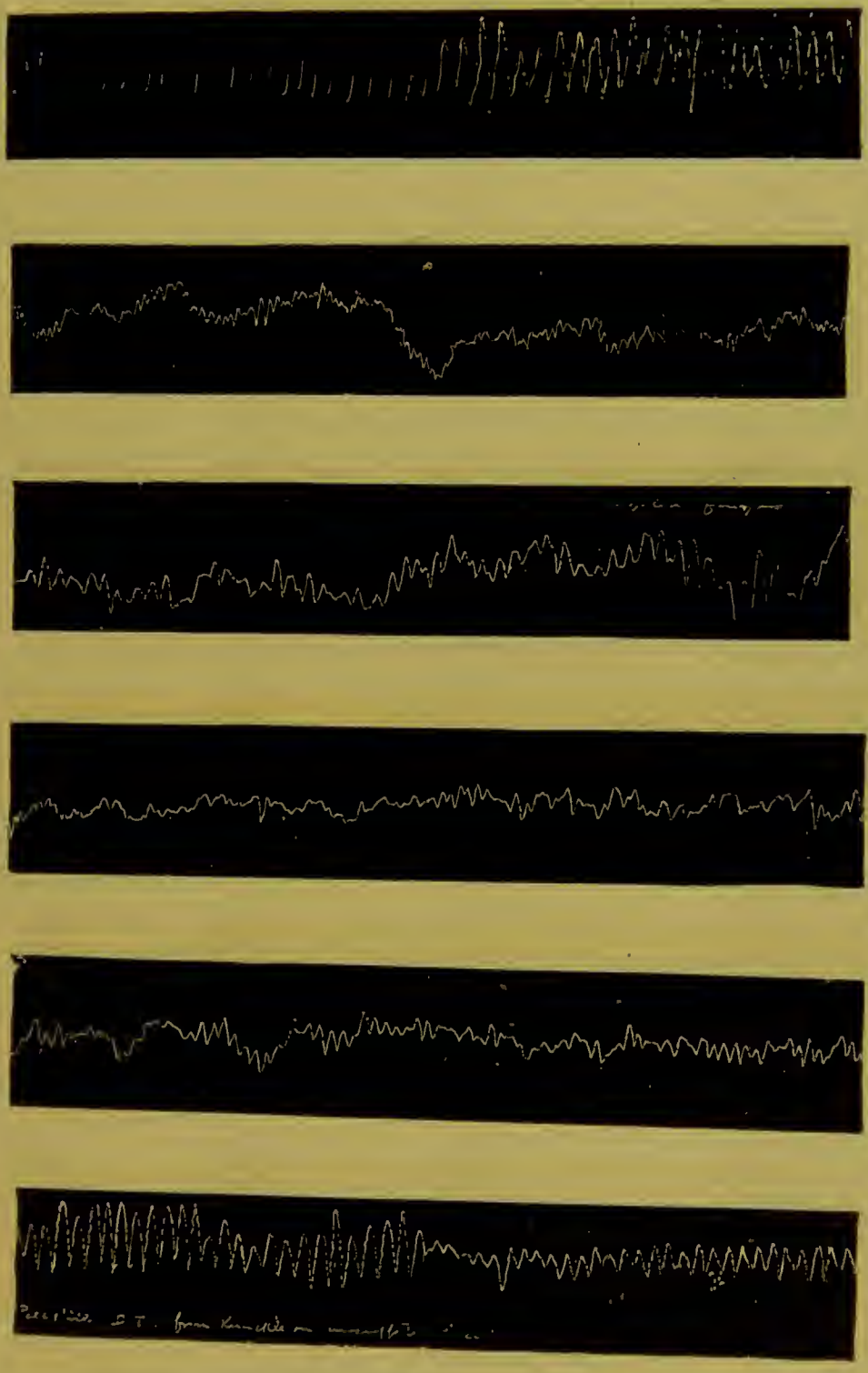
TEN SECONDS.



TREMOR OF MORBUS BASEDOWII.

1.	Taken from unsupported hand—wrists steadied against table,	12	per second.
2.	" " " " " "	8.7	"
3.	" " " " " "	9.9	"
4.	" " " " " "	10	"
5.	Taken from wrist, right side, hands at rest on table,	9.7	"
6.	" " " " " "	11.3	"

TEN SECONDS.



A COMPARATIVE SERIES OF MYOGRAMS OF VARIOUS TREMORS.

1.	Paralysis Agitans,	4·7	per second.
2.	Morbus Basedowii,	11·7	"
3.	Multiple Sclerosis,	5·4	"
4.	Hysterical Tremor,	7·7	"
5.	Neurasthenic Tremor,	7·4	"
6.	Delirium Tremens,	5·6	"

the gastrocnemius; unless the position of the foot be changed by the use of other muscles. My myograms of ankle clonus consequently are a strong contrast to all the others in point of symmetry of wave-length.

The tracings here presented all passed through the sphygmograph in ten seconds, and accordingly the waves of vibration may be counted and the rate per second determined. As did Huber with Marey's instrument, I found the rate of vibration in paralysis agitans variable in different parts of the body of the same individual. My determination of the average rate in this disease agrees with that of all other investigators (except Gowers), viz., 3.7 to 5.6 per second. The rate for the tremor of the head in one individual was 3.7 per second one day, while a few weeks later it varied from 4.4 to 4.8 per second. These differences are due in part to the variable volitional impulses, and also in part to a variable innervation rhythm, making the excursions greater at some moments than at others. As a rule, when the muscullar oscillations are coarser there will be fewer per second. The matter of the existence of tremor in the muscles of the head and neck in paralysis agitans, once denied by Charcot, receives now general confirmation I think by most observers.[12] In my tracings will be seen many differences in the rate of tremor in Parkinson's disease, where taken from the carpal extensors, from the head, from the interossei, or from the supinators and pronators. There is a manifest lack of that uniformity which is generally ascribed to this tremor, but the reasons for this have already been discussed. At the same time

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[12] I have seen five or six cases with undoubted tremor of the head, one where the tremor of the head was much greater than that of the arms. For cases of head tremor in Parkinson's disease, see the following authorities:

Oppolzer, *Spital Zeitung*, No. 17, 18, 1861.

Clement, *Lyon Medical*, No. 26, 1869.

Jones, British Med. Journal, 1873.

Westphal, *Charité Annalen*, iii. u. iv. Jahrg.

Demange, *Revue d. Med.*, ii., 1882.

Buzzard, Clinical Lectures on Dis. of the Nerv. Syst., 1883.

Huber, *locus cit.*

Gowers, *locus cit.* (8 out of 37 cases).

the movement is seen to be more rhythmical than that of multiple sclerosis, ordinary alcoholism, hysteria, neurasthenia or morbus Basedowii. In delirium tremens, however, my tracings are quite as regular as in paralysis agitans. It must be borne in mind that myograms are subject to the same modifications in character as are sphygmograms from the variable pressure brought to bear by the holder of the instrument upon the moving muscle or artery. Indeed, there is possibly more modification from this source in using the instrument for the record of muscular tremors, because some of the tremors develop only when the fingers or hand are unsupported. The operator can fairly remedy this, as far as his own steadiness in holding the instrument is concerned, by supporting his elbows or arms upon a table and being seated. The arms of the patient may be steadied against the table, but even then his respiratory movements may affect the myogram somewhat, because his arms are attached to the moving thorax. A real respiratory curve may be seen in some of my myograms, notably those of the tremor of exophthalmic goitre. None of these difficulties, however, alter the rate of rhythm and will not change other peculiar characteristics if reasonable care be taken.

The tremor of paralysis agitans is almost the only one, with the exception of shivering from cold or terror, developed when the body is in a state of rest. Nearly all the others belong to the category of intention tremors, or to a class originated when limbs are outstretched without support. I am not so sure but that the last-named are also intention tremors, since voluntary effort is required to extend a member. The number of oscillations in well-developed multiple sclerosis I find to be 4.6 to 6.3 per second, but in another case where the tremor is just beginning to be perceptible, the innervation rhymth is numerically greater, viz., 7.9 to 8.1 per second. In a case presenting symptoms common to both paralysis agitans and multiple sclerosis, I made a diagnosis of the latter disease upon the fact that the rate of vibration was almost twice as great as it would be in paralysis agitans. The tremor was slight

and an intention tremor in character to be sure, but cases of Parkinson's disease have also been cited with an intention tremor (Gowers). The great irregularity of oscillation in multiple sclerosis is well demonstrated in some of my myograms.

The tremor of morbus Basedowii is fine, irregular, and has an innervation rhythm of 8.7 to 12 per second, according to my observation. Marie, as already mentioned, found it 8 to 9 per second.

Hysterical tremor is also fine, lacking in uniformity of excursion, and rapid, attaining a rate by my measurement of 7.6 to 7.8 per second.

The tremor developed by alcoholic intoxication is very variable. In ordinary alcoholism it presents the characteristics of that in hysteria and exophthalmic goitre as regards fineness, irregularity and rate of motion. I determine the rate to be 8.5 to 11.2 per second, varying within that limit in different persons and in the same persons at different times. Delirium tremens, however, presents a slower rate, 5.6 to 6.8 per second in my investigation, and somewhat greater uniformity of movement.

The few myograms I have taken in neurasthenia have the character of the tremors of ordinary alcoholism, Basedow's disease and hysteria. The frequency is 7.4 or more per second.

If we compare the rates of some of these tremors with the normal innervation rhythm of muscle as determined by the experiments of Horsley and Schäfer already mentioned, and by Beaunis,[13] about 10 per second, we note at once the near coincidence of the more rapid tremors with the normal rate, and the fact that the slower oscillations of paralysis agitans, multiple sclerosis and delirium tremens are about half that rate. It would seem that just as ten impulses along a motor nerve combine to make one normal continuous muscular contraction, so under pathological conditions the impulses may affect the muscles singly or in fused groups of two or more to produce rapid or slow tremors.

[13] *Physiologie humaine*, 1876, page 273.

Recently Wolfenden and Williams,[14] with a special myographic apparatus, have demonstrated the dicrotic character of the oscillations in paralysis agitans and to some extent in disseminated sclerosis. They found the rate in morbus Basedowii to be 10.8 to 11.5, in paralysis agitans 5.1, in disseminated sclerosis 5.8, and in a case of lateral sclerosis 5.5 per second, figures which correspond closely with my own.

As regards the origin of these tremors, the usual hemiplegic progress of paralysis agitans, occasional inequality of pupils, the cessation of movement, as a rule, during sleep and other arguments, lead us to suppose a genesis of the vibratory contraction in the cerebral cortex. The tremor of fear is without doubt of cortical origin. That of multiple sclerosis is best explained as also developed from the motor areas of the brain, its jerky character being ascribed by Charcot and Gowers to resistance to motor conduction at sclerotic foci, and by Stephan[15] to resistance by sclerotic changes in the optic thalamus. With at least equal justice it seems to me we may surmise that all other tremors, save those fibrillary in character, must be generated by intermittent motor impulses from the gray matter of some portion of the central nervous system. However, until all the physiological facts are accurately determined, the whole matter of the finer pathological movements must remain obscure.

This contribution of mine to the study of tremors is rather in the nature of a preliminary report upon investigations in this direction. While there may not be sufficient data here to arouse any great hopefulness of the diagnostic value of this means of examination, still considerable light may be thrown upon the nature of tremor in general by the employment of this method, and it demonstrates at any rate that we have a convenient and delicate instrument at hand for recording vibratory muscular movements for future comparison and study.

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[14] British Med. Journal, May 19, 1888.

[15] *Archiv. f. Psychiatrie, Bd. xviii., S. 734, and Bd. xix. S. 18.*